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Effect of Home-applied Finishes on Physical Properties of Cotton Fabrics

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SUMMARY

Many cotton fabrics sold by the yard and in garments do not have a permanent finish. Other fabrics lose their finish in the first few launderings and no longer have the new, crisp appearance the homemaker wants. Therefore, it is a common practice for the homemaker to apply a starch or other finish, particularly to house dresses, shirts and children's clothes. Many finishes, in addition to the familiar starch, are available on the grocery shelves from which the homemaker must make a choice. This study was undertaken to obtain information which would be helpful to the homemaker in making a selection.

Four finishes, typical of those on the market, were chosen. They were starch, a long-lasting resin starch, a plastic starch containing some CMC (carboxymethyl cellulose) and CMC alone. CMC often is found in combination with other finishes and is used in many commercial laundries. Two concentrations of each finish were used. These finishes were applied to four types of cotton fabrics—batiste, broadcloth, percale and suiting. The effect of each finish on the rate of absorption and the amount of water absorbed, on the color and fading, and on changes in strength and color during storage was determined.

Absorbency is a property of fabrics which affects the comfort of clothing. Therefore, the absorbency of each fabric with each finish was determined. Three methods were used to measure absorption. In one method the fabric was used as a wick and the distance the water traveled upward during 11 minutes was measured. With the exception of the broadcloth, the fabrics which had been laundered once but had no finish added, were more absorbent than when a finish was added. For broadcloth, CMC increased the absorption over no finish. At a low concentration of finish, plastic was the most absorbent finish for three of four fabrics. At a high concentration, resin and starch were more absorbent than CMC and the plastic containing CMC for three fabrics. Suiting was the most absorbent fabric, broadcloth the least absorbent and there was little difference between batiste and percale.

In the second method, the amount of water absorbed by a fabric after 10 minutes of immersion was used as a measure of the absorption by the fabrics. By this method the fabrics with no finish absorbed little more than the fabrics as purchased. The CMC and the plastic finishes had the highest absorption followed by starch and resin. An increase in concentration of the finish increased the absorption of CMC and of starch and had little effect on plastic and resin. Suiting was the most absorbent and broadcloth the least absorbent of the fabrics.

In the third method of measuring absorption, the rate of absorption and the amount of water absorbed in 5 minutes were determined. The water came in contact with one surface of the fabric as if it were a blotter. This method most resembles the way clothing comes in contact with perspiration. Suiting was the most absorbent fabric and broadcloth the least absorbent. The CMC and the plastic finishes absorbed water at a faster rate and absorbed more water than the resin or starch. This greater absorbency of CMC and plastic and the greater ability of fabrics with these finishes to "breathe" probably are the reasons men reported in a previous study that shirts finished with CMC and with plastic were more comfortable than those finished with the starch and resin finishes.

Factors which probably caused the differences between the fabrics in absorption are the differences in size and twist of yarns, number of yarns per inch, tension of yarns, size of spaces between yarns and fibers, the evenness of the spaces and perhaps even the cotton fibers themselves.

To see if these finishes affected the color of the fabrics and their resistance to fading, each fabric with each finish was inspected for visible differences and the color was measured with a reflectometer when the finish was first applied and after 140 hours of fading in a Fade-Ometer. The differences between finishes were too slight to cause the consumer concern.

Six of the fabrics without a finish and with each of the four finishes were stored for 3 years in three locations—an attic, a vault and in a textile laboratory. There were 116 days with temperatures of 100° F. or above in the attic and 8 such days in the vault. The strength of the fabric was determined before storage and after storage to see what effect each finish had on strength during storage. The small differences in strength between finishes and locations of storage were not significant. There were no changes in color during storage. These findings indicate that cotton fabrics can be starched or given one of these other finishes before storage and stored for at least 3 years without danger of deterioration in strength or color.

Effect of Home-applied Finishes on Physical Properties of Cotton Fabrics

Mary Anna Grimes and Cynthia M. Dillin*

MANY HOMEMAKERS ARE NOT SATISFIED with the appearance of cotton fabrics, particularly after they have been in use for some time and have lost their original crispness and new appearance. Therefore, a finish is applied for one or more reasons, to increase crispness or stiffness, add a gloss, increase resistance to soiling and ease of washing and ironing, or to restore or improve the original appearance. Homemakers do not usually apply a finish to those fabrics which carry a label stating that the finish is "permanent" or that they are "drip dry" or "wash and wear" fabrics. As these fabrics become older and become somewhat limp a finish is often applied to restore the original body. There are many cotton fabrics sold by the yard and in garments which contain no permanent finish and which do not have the properties the homemaker hopes to give them by adding a finish.

Starch was once the only available finish but now many newer finishes are on the grocery shelves from which the homemaker may make a choice. This study of the effect of some of the available finishes on properties of cotton fabrics was made to gain information helpful to the homemaker in choosing a finish to satisfy her needs.

Four finishes were included, common laundry starch, CMC (carboxymethyl cellulose) used alone, plastic starch containing some CMC, and resin. CMC often is found in combination with other finishes, and it is used in many commercial laundries. A portion of each fabric was left without finish so that comparisons could be made with the same fabric after the application of the finishes. The effect of these four finishes on the absorption, color and resistance to loss in strength during storage of four types of fabrics is reported.

FABRICS AND FINISHES

Thirteen fabrics were used in this study. However, since some of the fabrics differed only in color, a few are not included in all sections of this report. Four widely different types of fabrics were used — batiste, broadcloth, percale and suiting. None of the fabrics had been given a semi-permanent, permanent or resin finish by the commercial finisher.

The fabrics used were quite different in construction. The broadcloth differed widely from the other fabrics in the relation of the number per inch of warp yarns to filling yarns. The broadcloth had 122 warp and 59 filling yarns per inch, the batiste 98 in each direction, the percale 89 warp and 71 filling, and the suiting had 55 warp and 48 filling.

The fabrics were studied under three conditions: as they were purchased, after they had been laundered once to remove any sizing added during manufacture but with no finish added and after each of the four finishes was applied.

The finishes used were carboxymethyl cellulose (CMC), starch, a long-lasting resin and a plastic finish containing some CMC. These finishes were used in a previous study (3).

Two concentrations of finishes were used. For the lower of the two concentrations 1 tablespoon of starch to 1 quart of water gave light starching. The proportion of plastic starch to water was 1 to 6. For the CMC finish 57 grams

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of CMC were dissolved in 6 quarts of hot water. The proportions of the resin finish to water was 1 to 4. For the higher concentration of each finish the proportion of finish to water was doubled.

EFFECT OF FINISHES ON ABSORBENCY OF FABRICS

The rate at which a fabric takes up moisture and the amount of moisture it absorbs affects the comfort of clothing. Any finish added to a fabric to enhance appearance, prevent wrinkling, increase ease of laundering or otherwise modify the properties of the fabric may also change its absorbency, hence affect comfort.

This portion of the study was undertaken to determine the effect of four finishes on the absorption of water by cotton fabrics. The absorbency of the fabric was determined for each fabric as it was purchased, laundered once but no finish added and after the addition of a finish in each of the two concentrations.

Three methods of measuring the absorption of water by fabrics were used. These were the wicking method (4), static immersion (1) and the method developed at the Southern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture, hereafter called the SURDD method (2).

Absorbency of Fabrics by Wicking

For the wicking method reported by Holland (5) specimens were cut 1 inch by 6 inches with the warp running in the long direction. One end of a specimen was attached to a 5-gram weight with a small wire hook. The strip was suspended in distilled water so that 1 inch of the lower end was immersed. A ruler was mounted at the side of the strip so that the height of the absorption could be measured in tenths of an inch at any desired time interval. Readings were taken at intervals of 15, 60, 90 and 120 seconds and at 60-second intervals until the entire absorption time totaled 11 minutes. The average for five specimens was considered a measure of the absorbency of that fabric.

To determine if the differences in absorption during 11 minutes were real or chance, t values were calculated. The differences were considered real if the t values were at the 5 percent level or lower.

Batiste. There were wide differences in the rate of absorption by wicking among the various finishes on batiste.

After 11 minutes the batiste with CMC at the low concentration had absorbed water to a height of only .7 inch, resin 1.4, starch 1.7, plastic 2.1, batiste as purchased 2.6 and laundered but with no finish added 3.3 inches, Figure 1.

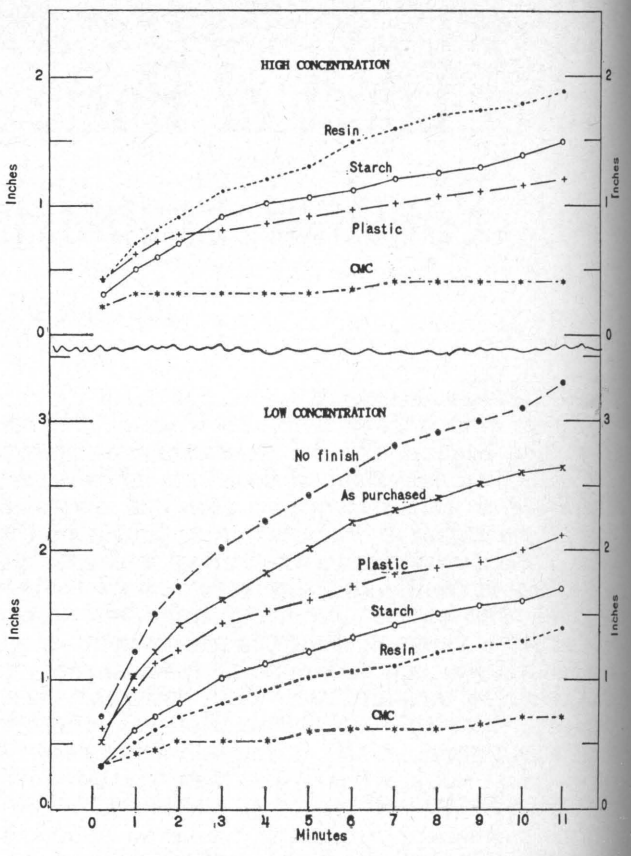

Figure 1. Rate of absorption by wicking of green batiste with two concentrations of finish.

An increase in the concentration of the finish decreased the rate of absorption when the finish was plastic, CMC and starch but increased the rate for the resin finish, Figure 1. The greatest decrease in absorption with an increase in concentration occurred with the plastic finish, from approximately 2 inches to slightly above 1 inch.

The greater absorbency of the batiste without a finish over that of the finished batiste was significant at the .1 percent level. The greater absorbency of the batiste as purchased over the batiste with finishes at the low concentration was significant at the .1 percent level for three finishes and at the 1 percent level for the fourth finish, plastic.

Comparisons between the two concentrations show that the absorption was greater at the low concentration for starch, plastic and CMC. The difference was significant at the .1 percent level for plastic and CMC and at the 1 percent level for starch. The high concentration of the resin was more absorbent than the low concentration. The significance was at the 1 percent level.

Broadcloth. The broadcloth was less absorbent than the other fabrics. As purchased, no absorption was visible until 4 minutes of wicking and after 11 minutes the water had traveled upward only .15 inch, Figure 2. After laundering, but with no finish added, the absorption after 11 minutes had increased to .6 inch.

For the low concentration no absorption occurred, even after 11 minutes, in the broadcloth finished with starch and with resin. The test was repeated with other strips with the same results. The broadcloth with CMC absorbed water more rapidly than with the other finishes. The plastic containing CMC had approximately the same rate of absorption as the fabric with no finish. After 11 minutes the broadcloth with no finish and with CMC had absorbed approximately the same.

An increase in concentration of the CMC and of the plastic decreased the rate of absorption but an increase in the concentration of starch greatly increased the rate of absorption. There was no absorption with the high concentration of resin, nor did a repetition of the test show an increase, Figure 2.

The greater rate of absorption of broadcloth with no finish over the broadcloth as purchased was significant at the .1 percent level and over that with plastic was significant at the 2 percent level. The greater rate of absorption of the low concentration of plastic and CMC finishes over broadcloth as purchased was significant at the .1 percent level. An increase in the concentration of CMC significantly lowered the rate of absorption.

Percale. The green percale had much greater absorbency when laundered than as purchased, Figure 3.

The addition of each finish decreased the absorbency from that of the percale with no finish. For the low concentration the most absorbent finish was plastic, followed in order by resin, starch and CMC. In 11 minutes the water had moved upward 2.3 inches in the plastic-finished fabric, but only .8 inch in the CMC-finished percale.

After 11 minutes of absorption with the low concentration of finish, the significance of the

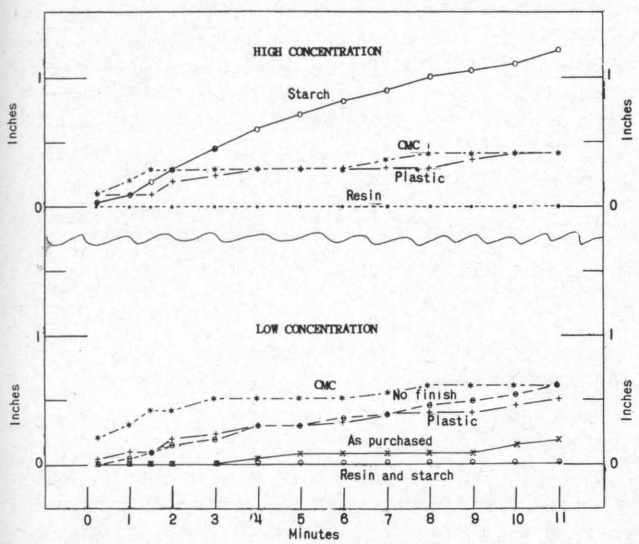

Figure 2. Rate of absorption by wicking of white broadcloth with two concentrations of finish.

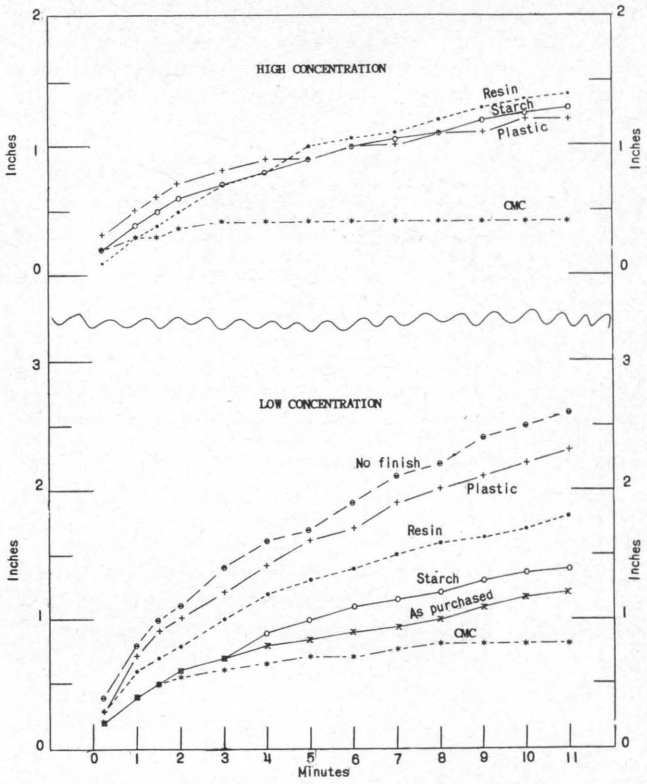

Figure 3. Rate of absorption by wicking of green percale with two concentrations of finish.

absorbency of the percale with no finish over the finishes was at the .1 percent level for three finishes and at the 1 percent level for the plastic finish. The absorbency of the percale was significantly greater as purchased than when CMC was added. The addition of resin and plastic significantly increased the rate of absorption over that of the percale as purchased. Starch was significantly less absorbent than plastic and resin but significantly more absorbent than CMC. Plastic was significantly more absorbent than CMC and resin, and resin was more absorbent than CMC.

An increase in the concentration decreased the rate of absorption for all finishes, Figure 3. Plastic and CMC-finished percales showed the greatest decrease. At 4 and 5 minutes there were small differences among resin, starch and plastic in their absorption of water.

Suiting. As with the other fabrics, laundering increased the absorbency of the suiting. The travel of the water after 11 minutes was increased nearly 1 inch, Figure 4.

The addition of the four finishes decreased the rate of absorption from that of the fabric with no finish.

At the low concentration, the resin and plastic finishes were the most absorbent of the finishes and were approximately equal. CMC absorbed water more rapidly than starch; they had absorbed equally at 7 minutes but at 11 minutes the water had traveled farther in starch.

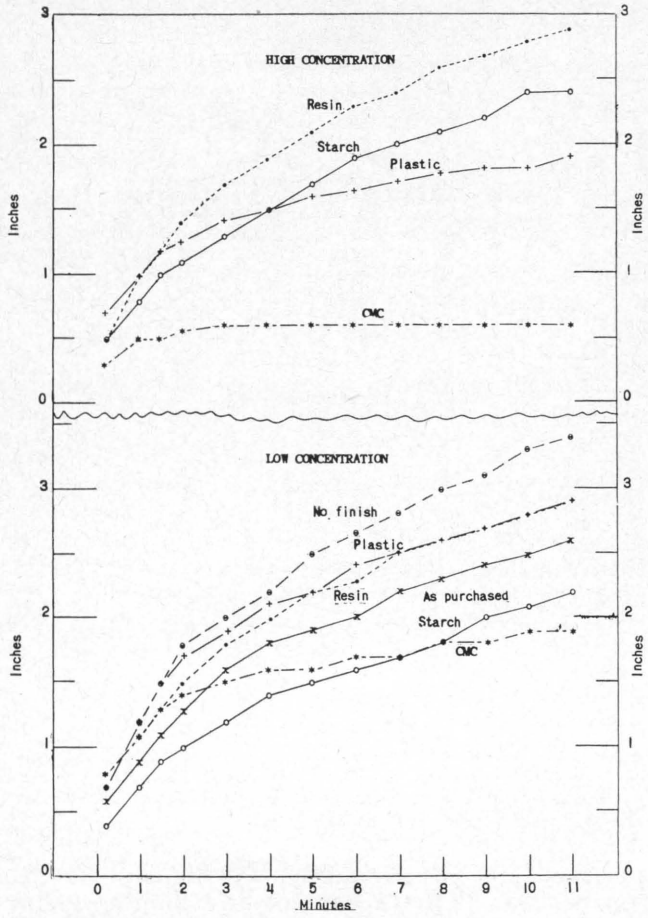

Figure 4. Rate of absorption by wicking of green suiting with two concentrations of finish.

After 11 minutes of absorption the suiting with no finish was significantly more absorbent than as purchased or with a finish. The difference was significant at the .1 percent level except for resin where it was at the 1 percent level. The suiting as purchased was significantly more absorbent than with starch and CMC, but significantly less absorbent than with plastic and resin. Plastic and resin finishes were significantly more absorbent than CMC.

An increase in concentration slightly increased the rate of absorption for starch, made no difference in resin and decreased greatly that of plastic and CMC, Figure 4. After 2 minutes the rate of absorption of CMC became much slower as is shown by the shape of the curve.

DIFFERENCES AMONG FINISHES

Laundering of each fabric increased the rate of absorption from that of the fabric as purchased. This increase was probably caused not so much by the removal of any soluble sizing or finish added by the manufacturer, as by the shifting of the yarns to make more uniform spaces between yarns (2). The laundered fabrics with no added finish were more absorbent than when a finish was added, with the exception of the broadcloth with the high concentration of starch.

Of the four finishes at the low concentration, the plastic was the most absorbent in batiste and percale and the same as resin in the suiting. Where it was absorbent, the resin was more absorbent in percale and suiting and less in batiste than the starch. Resin finished broadcloth was not absorbent. CMC was in all cases the least absorbent finish. The plastic finish contained some CMC, but evidently not in sufficient quantity to decrease the absorbency.

DIFFERENCES AMONG FABRICS

The fabrics used were quite different in type. The construction of the broadcloth differed from the other fabrics in that there were more warp yarns in relation to filling yarns per inch. All strips were cut so that the warp ran lengthwise, therefore the water traveled upward along the closely packed warp yarns as it was absorbed. The closeness of the warp yarns probably affected the absorption of the fabric. In all cases the broadcloth was the least absorbent fabric.

Batiste is a very fine, soft fabric. With no finish it was the most absorbent fabric. With a finish added it had approximately the same absorbency as the percale.

Percale as purchased and after laundering but with no finish added was more absorbent

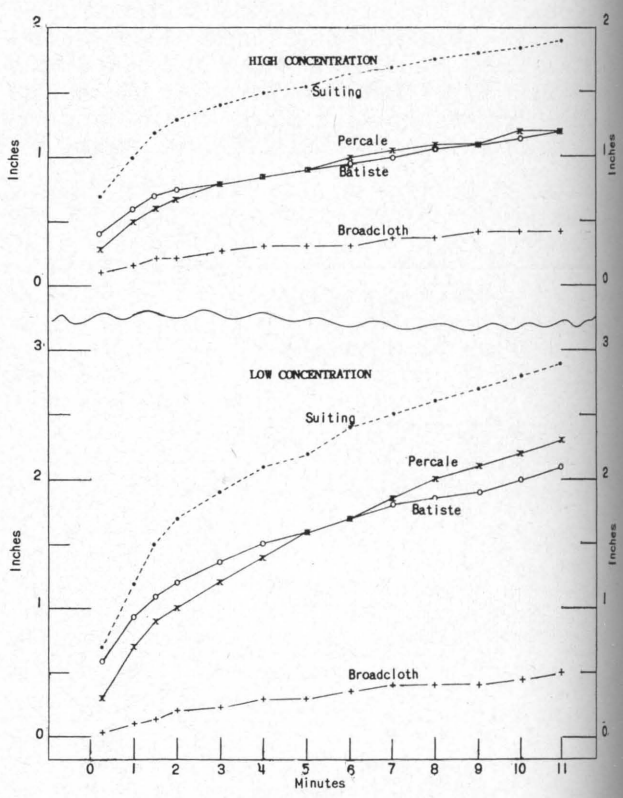

Figure 5. Rate of absorption by wicking of plastic finish in two concentrations on each of four fabrics.

than the broadcloth and less absorbent than the batiste and suiting.

The suiting was the heaviest and coarsest of the fabrics. The batiste and suiting, quite unlike in yarn size, had approximately the same absorbency as purchased and with no finish. However, the suiting was more absorbent for each concentration of all finishes.

In all fabrics the absorption was more rapid during the first 1 or 2 minutes of wicking.

The difference between fabrics in the rate of absorption by wicking is illustrated in Figure 5 which gives the rate of absorption of plastic finish at each concentration for each of four fabrics. At each concentration the suiting was the most absorbent and the broadcloth the least absorbent fabric. Percale and batiste differ little and were less absorbent than suiting and more absorbent than broadcloth.

Factors which probably affected the rate of absorption include differences in size and twist of the yarns, yarns per inch, tension of yarns, size of spaces between fibers and yarns, the evenness of the spaces and perhaps even the cotton fibers themselves.

Absorbency of Fabrics when Immersed

A modification of the static (immersion) test approved by the American Standards Association and recommended by the ASTM was another method used to determine the quantity of water held by the fabric with the various finishes and concentrations when the fabrics were immersed in water at room temperature (1). Standard conditions of 70±2 °F and 65±2% RH were maintained.

Three squares of the fabric, 4 by 4 inches, were used. The preweighed squares were immersed in distilled water for 10 minutes. The wet fabric had excess water removed by placing it between white AATCC textile blotting paper and passing a 10-pound roller across the top blotter. The square of fabric was immediately placed in a weighing bottle and weighed. The difference between the wet and dry weight of the fabric expressed as a percentage of the dry weight was considered the absorption by the fabric. An average of three specimens was used for each fabric and finish. Table 1 gives the absorption for each fabric and finish.

Batiste. There was no significant difference in the amount of water absorbed by the batiste as purchased and after laundering. The addition of a finish significantly increased the absorbency above no finish for plastic and CMC, but lowered it for resin. The difference was not significant for starch, but was significant at the 2 percent level for plastic and resin and at the 1 percent level for CMC.

TABLE 1. WATER ABSORBED BY IMMERSED FABRIC EXPRESSED AS A PERCENTAGE OF THE DRY WEIGHT OF THE FABRIC

Fabric	As purchased	None[1]	CMC	Plastic	Resin	Starch
			Low concentration			
Batiste	65.5	64.8	73.1	69.9	58.3	66.4
Broadcloth	60.9	60.9	74.4	64.3	57.9	53.6
Percale	56.4	61.5	67.3	65.9	60.5	63.9
Suiting	69.4	70.4	78.0	71.2	68.6	70.5
Average	63.0	64.4	73.2	67.8	61.3	63.6
			High concentration			
Batiste	65.5	64.8	72.8	68.1	61.1	72.5
Broadcloth	60.9	60.9	81.9	66.6	58.8	63.7
Percale	56.4	61.5	71.9	65.2	59.5	66.0
Suiting	69.4	70.4	82.3	74.2	67.9	72.7
Average	63.0	64.4	77.2	68.5	61.8	68.7

[1]Sizing removed.

An increase in the concentration significantly increased the absorbency of the starch, but had no significant effect on the other finishes.

Broadcloth. Laundering did not change the absorbency of the broadcloth. The CMC was more absorbent than the other finishes. The difference between CMC and the other finishes was significant at the .1 percent level for comparisons with starch and resin, at the 1 percent level for none and plastic and at the 2 percent level for the broadcloth as purchased. For the high concentration the CMC was more absorbent than all other finishes. The significance was at the 1 percent level for all but plastic where it was at the .1 percent level.

An increase in concentration of the finish increased the absorbency for starch and CMC, but had no significant effect on plastic and resin.

Percale. Laundering of percale significantly increased the absorbency. The absorbency of starched percale was significantly greater than for the fabric as purchased or with no finish.

The addition of CMC increased the absorbency in all comparisons except in the comparison with plastic. The differences in absorbency were significant at the 1, 2 and 5 percent levels.

Resin had no significant effect on the absorption.

An increase in concentration of the finishes did not affect significantly the absorbency with one exception. The increase in absorbency with an increase in concentration of CMC was significant at the 1 percent level.

Suiting. Laundering had no significant effect on the absorbency of suiting. Of the finishes only CMC significantly increased the absorbency above no finish. At the low concentration the differences were significant at the 5 percent level between CMC and each of the finishes but resin where the significance was at the 2 percent level. Starch was significantly more absorbent than resin.

At the high concentration plastic was more absorbent than the fabric as purchased or with resin. Starch was more absorbent than resin.

CMC was much more absorbent than the other finishes. The differences were significant at the 1 percent level for CMC over no finish, as purchased, starch and resin and at the 2 percent level for plastic.

Starch was the only finish for which an increase in concentration increased the absorbency of the suiting. The increase was significant at the 2 percent level.

DIFFERENCES AMONG FINISHES

When immersed in water the CMC at each concentration was the most absorbent finish for all the fabrics. An increase in concentration of CMC significantly increased the absorbency of the broadcloth and percale. The more concentrated solution of starch was more absorbent than the low concentration on batiste, broadcloth and suiting. The differences were significant at the 5 percent level for batiste and broadcloth and at the 2 percent level for suiting.

DIFFERENCES AMONG FABRICS

As purchased, the suiting was the most absorbent fabric when immersed, followed in order by batiste, broadcloth and percale. The absorbency increased in laundering only in percale. This suggests that any soluble finish which may have been added by the finisher to batiste, broadcloth and suiting did not alter the absorbency of these fabrics when they were immersed in water.

From the immersion method of determining absorption it is concluded that CMC is the most absorbent finish, followed in order by plastic, starch and resin. This is quite different from the absorption of the same finishes by the wicking method where CMC was the least absorbent and starch and resin were more absorbent than plastic. By the wicking method the fabrics were more absorbent with no finish, but by the immersion method the addition of CMC and plastic increased the amount of water absorbed.

Wicking and immersion methods used to measure absorption do not measure the same thing. No measurement is made of *quantity* of water held by the fabric in the wicking method, instead *rate* of absorption is determined. By the immersion method, comparisons are made of the quantity of water held by each fabric under the same conditions.

Rate and Ultimate Absorption

A third method of measuring absorbency with the use of a device modeled after one developed at the SURDD was used (2). A modification of the device was made for ease of use by mounting the three most used flowmeters so a selection could be made by turning the proper stopcock. All readings were made at zero head, that is, when the height of the source tube from which the water came minus the height of the plate through which the water passed into the fabric was zero. Two determinations were made, the maximum rate of flow read from the float in the tube and the amount of water absorbed in 5 minutes. The latter has previously been called the ultimate absorption but the float had rarely dropped to zero at the end of 5 minutes, therefore, the fabrics had presumably not ceased absorbing water.

The maximum rate of flow and the absorption in 5 minutes for each fabric, finish and concentration of finish are given in Table 2.

Batiste. The removal of sizing from batiste did not affect the rate of absorption or amount of water absorbed. Probably there was little soluble sizing in the fabric as purchased. There were slight differences in both rate and amount of absorption among two finishes for batiste, (CMC and plastic) and as purchased and no finish. However, both resin and starch had less absorption in rate and amount than the other finishes. An increase in concentration of finish had no significant effect on either rate of absorption or amount of water absorbed.

Broadcloth. The removal of sizing from broadcloth slightly increased the rate of flow and greatly increased the amount absorbed. At the low concentration the rate was higher but the amount absorbed was lower for resin than for the other finishes. At the end of 5 minutes the broadcloth with no finish, CMC and plastic had absorbed the most water and approximately equal amounts. An increase in concentration of resin significantly decreased the absorbency but had no significant effect on CMC, plastic and starch.

Percale. For percale, the removal of sizing did not affect the rate of absorption but greatly increased the quantity absorbed. At the low concentration, CMC had the highest rate and total absorption of the finishes, followed by plastic. Resin-finished percale had the lowest rate of absorption of the finishes but starch absorbed less water than resin. At the high concentration the rate of absorption for CMC and plastic was higher and for resin and starch lower than at the low concentration. An increase in concentration decreased the total absorption for all finishes except starch.

Suiting. The removal of sizing increased the rate of absorption of suiting but had no significant effect on the amount absorbed. The fabric with no finish and with CMC had the highest rate of absorption at the low concentration followed in order by plastic, resin and starch. For the high concentration, the rate of absorption was highest for plastic, followed by CMC, resin and

TABLE 2. THE MAXIMUM RATE OF ABSORPTION AND AMOUNT OF WATER ABSORBED BY SURDD METHOD

Fabric and finish	Maximum flow rate $cm.^3/sec.$	Absorption in 5 min. (zero head) ml.
Batiste		
As purchased	2.83	1.90
None[1]	2.77	2.02
	Low concentration	
CMC	2.73	2.02
Plastic	2.85	2.06
Resin	2.05	1.90
Starch	1.70	1.84
	High concentration	
CMC	2.49	1.82
Plastic	2.83	1.96
Resin	2.00	1.40
Starch	1.70	1.72
Broadcloth		
As purchased	1.07	0.98
None[1]	1.15	1.92
	Low concentration	
CMC	1.56	1.98
Plastic	1.27	1.88
Resin	1.65	1.08
Starch	1.27	1.12
	High concentration	
CMC	1.56	1.73
Plastic	1.37	1.88
Resin	1.43	0.90
Starch	1.20	1.20
Percale		
As purchased	1.56	1.80
None[1]	1.60	2.40
	Low concentration	
CMC	2.57	2.74
Plastic	1.95	2.40
Resin	1.15	2.10
Starch	1.70	1.34
	High concentration	
CMC	2.73	2.32
Plastic	2.27	2.32
Resin	0.57	1.56
Starch	1.23	2.04
Suiting		
As purchased	3.63	3.08
None[1]	4.03	3.15
	Low concentration	
CMC	4.06	3.18
Plastic	3.54	3.12
Resin	3.33	3.08
Starch	3.05	3.02
	High concentration	
CMC	3.27	3.02
Plastic	3.88	3.24
Resin	3.00	2.99
Starch	2.45	2.86

[1]Sizing removed.

starch. An increase in concentration lowered the rate of absorption for CMC, resin and starch but slightly raised that of plastic. With the exception of plastic an increase in concentration lowered the amount of water absorbed but the differences are not significant.

DIFFERENCES AMONG FINISHES

In general, CMC and the plastic finish which contained CMC, were the most absorbent and resin and starch the least absorbent finishes by this method of measuring absorption. These ratings correspond closely to those obtained by the immersion method where the weight of water absorbed was used as the measure of the fabric's absorption. The differences between the two methods are not significant. However, there are some disagreements between these two methods of measuring absorbency and the wicking method. These may be because of the differences in point of contact of the fabric with the water. In the wicking method the water travels upward along the yarns; in the immersion method all sides of the fabric come in contact with the water. In the SURDD method the water comes in contact with one surface of the fabric. This last method most resembles the manner in which fabrics come in contact with the perspiration of wearers of clothing, therefore, it probably is the best measure of the absorbency of fabrics as absorbency affects the comfort of clothing.

The same broadcloth and the low concentration of the same finishes were used in a previous study in which the wearers of broadcloth shirts stated that for comfort in sport shirts, they preferred no finish, plastic and CMC to resin and starch (4). The greater comfort of fabrics with no finish, CMC and plastic over starch and resin is probably because of their ability to absorb more perspiration. CMC finished fabrics are also more permeable to air than the other finishes, a property contributing to comfort (3). The ultimate absorption of broadcloth with no finish, with plastic and with CMC is much higher than for the same broadcloth with resin or starch. Presumably, on the basis of comfort the choice between these finishes lies between plastic and CMC.

DIFFERENCES AMONG FABRICS

There were large differences among fabrics in both rate of absorption and amount of water absorbed. In all cases, suiting, with coarse yarns and few to the square inch, absorbed at a higher rate and a larger quantity of water than any other fabric, approximately three times that of broadcloth. Batiste, a soft, fine, thin fabric followed suiting. Percale with a close weave was next in order and broadcloth was last with the lowest rate and lowest total absorption. Construction is of major importance in determining the rate and ultimate absorption.

EFFECT OF FINISHES ON COLOR OF FABRICS

To determine the effect of each finish on the color of the fabrics comparisons were made of each fabric between various stages — as purchased, with the sizing removed, and after the application of a finish; between finishes; and between the fabrics before and after 140 hours of exposure in a Fade-Ometer. For most of these comparisons the lower of the two concentrations was used. To determine the effect of concentration of finish on color, two concentrations, one twice that of the other, were used on three fabrics.

Two methods were used to evaluate changes in color. Visual inspection was made by three observers working independently. Measurements were made of the reflectance with a Hunter multipurpose reflectometer using three filters—amber, blue and green. A standard closely resembling the color of each fabric was used in the reflectometer to compare the color of the fabric without and with a finish and after exposure in the Fade-Ometer. Precaution was taken to keep the instrument errors as small as possible. However, Hunter has stated that a tristimulus colorimeter giving apparent reflectance imprecise by .001 will not identify color differences as small as those which the trained color inspector can distinguish (6). Therefore, it seems reasonable to assume that the differences noted by the observers were a satisfactory measure of changes in color.

The reflectance readings were used in two ways. Color differences were calculated using the formula recommended by Hunter as a satisfactory measure of the amount of color change resulting from exposure or other treatments (6). These color differences give the magnitude of the color change. The percentage change in reflectance, using the fabric as purchased as 100 percent, was calculated from the reflectometer readings. When the percentage was above 100 percent the fabric had in most cases been judged to be lighter and below 100 percent to be darker than the original fabric. Thus, the percentage was used to determine whether the fabric had become lighter or darker than the original fabric or had changed hue.

Effect of Application of Finishes

VISUAL INSPECTION AND REFLECTANCE

All fabrics were given one laundering to remove any soluble sizing. Any change in color during laundering may have been caused by the removal of sizing or by lack of fastness of the dye or by both. When the fabric became darker after laundering it seemed probable that the sizing had made it lighter.

Although the differences in color were slight, the observers thought the addition of the finish in some cases affected the color of the fabric. However, the same finish did not affect all fabrics alike.

CMC was thought to have made no fabric lighter but slightly darkened green, blue and yellow percale. The colors of four fabrics were not changed. These judgements are close to the measurements with the reflectometer. The observers agreed that CMC had slightly changed the hue of the blue percale so it was slightly purple. This judgement was verified by the reflectometer as the reflectance with the blue filter was lower in relation to the unfinished fabric than for any other finish applied to the blue percale.

The plastic finish appeared to make green and red suiting and blue and purple percale slightly lighter, blue batiste, green and yellow percale slightly darker, and did not affect the color of the pink batiste. Again these judgements agree in general with the reflectometer readings.

Resin was thought to have slightly darkened green percale, blue and pink batiste and made no difference in the color of five fabrics.

The observers noted that starch slightly darkened yellow percale and did not change the color of seven fabrics.

With the exception of resin on green batiste and starch on green suiting the fabrics were slightly darker at the high than at the low concentration.

In general the judgements of the observers agreed with the reflectometer readings. In no case did the observers believe the application of a finish caused enough change in color to be objectionable.

COLOR DIFFERENCES

Color differences between the fabric as purchased and with the sizing removed and between the fabric as purchased and with each finish added were calculated from the reflectometer readings and are given in Table 3.

The first column, which gives the effect of the removal of sizing, shows that one laundering made a difference in the color of the 11 fabrics. The color difference units were small for four fabrics, approximately one, but above three for four fabrics. Most of the fabrics were darker after the sizing was removed with the exception of the blue and green batistes. The green percale B was more yellow after the sizing was removed.

With the exception of the green batiste, CMC had little effect on the color of the fabrics as shown by the close resemblance of the color difference units to those for the desized fabrics. An increase in concentration made green batiste nearer the color of the unlaundered fabric, had

TABLE 3. DIFFERENCE BETWEEN FABRICS AS PURCHASED AND AFTER THE ADDITION OF FINISH EXPRESSED IN COLOR DIFFERENCE UNITS

Fabric		Finish				
		None[1]	CMC	Plastic	Resin	Starch
Batiste, blue		1.4	2.5	1.8	2.1	2.3
Batiste, pink		1.0	2.1	1.4	2.0	2.7
Percale, blue		1.0	0.8	1.0	1.0	1.0
Percale A, green		3.4	3.4	3.4	3.4	0
Percale, purple		1.0	1.0	1.5	1.0	2.3
Percale, yellow		3.9	2.9	0.1	1.5	3.5
Suiting A, green		1.2	1.2	1.2	1.2	1.2
Suiting, red		1.0	1.1	0.7	0.2	1.6
Batiste, green	Low conc.	5.2	3.5	3.2	3.6	4.6
	High conc.		2.5	2.6	4.5	4.6
Percale B, green	Low conc.	2.7	2.6	2.6	2.6	2.2
	High conc.		3.1	4.4	3.4	3.9
Suiting B, green	Low conc.	3.5	3.5	3.5	3.5	3.5
	High conc.		3.5	3.5	3.5	3.1

[1]Sizing removed.

little effect on green percale and did not change the color of the green suiting.

Plastic did not affect the color of most of the fabrics. It restored the color of one fabric, yellow percale, to that of the sized fabric. Green batiste was slightly darker at the high than at the low concentration of plastic.

As shown by the size of the color difference units the resin finish had no effect on the color of six fabrics. It slightly darkened five fabrics. An increase in concentration had little effect on the color.

Starch had little effect on the color of most of the fabrics. The greatest effects were on the batistes and the purple percale. An increase in the concentration of the starch made the green percale slightly darker but had no effect on the green suiting and batiste.

The average of color difference units for the desized, the CMC and the starch finished fabrics were almost the same but the resin and the plastic were slightly smaller. This indicates that, in general, the addition of the resin and plastic more successfully restored the fabric to the color as purchased than did the starch and CMC.

An increase in the concentration of each finish made the green percale darker than at the low concentration. For the green batiste, the high concentration of plastic, resin and starch resulted in a lighter color but with the high concentration of CMC the color was slightly darker than with the low concentration. Neither the finish nor concentration of finish affected the color of green suiting.

The difference between finishes in their effect on color are so slight that they would not cause the average consumer concern.

Effect of Finishes on Fading

VISUAL INSPECTION AND REFLECTANCE

To learn if these finishes affected fading, each fabric without a finish and with each of the four finishes was exposed to 140 hours of fading in a Fade-Ometer. The observers noted differences in color between the unfinished and finished fabric. Reflectance measurements were made of the same fabrics.

After 140 hours of fading all fabrics with the exception of the green suiting, which was of remarkably fast color, showed considerable fading. In a number of instances the observers differed slightly in their judgements indicating that the differences, if any, were slight. In two cases the fabrics with no finish, and with resin were thought to be faded slightly more than those with plastic and CMC which were thought equally faded.

COLOR DIFFERENCES

Color differences for the exposed fabrics were calculated from the reflectometer reading. The fabric as purchased was used as the standard with which the desized and finished fabrics were compared. The color differences are given in Table 4.

The color differences resulting from desizing were from 0 for the green suiting to 15.9 for the yellow percale. On the basis of averages the removal of sizing and the application of resin resulted in the greatest color differences and were approximately the same. The average color differences for starch and CMC finished fabrics were equal and somewhat less than the fabrics without finish and with resin. The average of the color differences for the plastic finish was the

TABLE 4. DIFFERENCE BETWEEN FABRICS AS PURCHASED AND AFTER THE ADDITION OF FINISHES AND EXPOSED 140 HOURS IN FADE-OMETER EXPRESSED IN COLOR DIFFERENCE UNITS

Fabric		Finish				
		None[1]	CMC	Plastic	Resin	Starch
Batiste, blue		6.9	8.2	5.4	5.7	6.4
Batiste, pink		1.7	2.6	2.3	3.0	1.2
Percale, blue		2.0	0.7	0.7	1.3	0.7
Percale A, green		1.1	1.1	1.2	2.0	1.1
Percale, purple		1.4	1.7	1.3	2.3	1.7
Percale, yellow		15.9	9.7	10.7	12.8	6.9
Suiting A, green		0	0	0	0	0
Suiting, red		5.6	4.6	5.2	3.8	5.0
Batiste, green	Low conc.	11.7	8.3	9.1	13.8	13.0
	High conc.		8.7	10.4	8.9	7.2
Percale B, green	Low conc.	1.5	1.7	1.3	2.7	2.4
	High conc.		2.3	1.4	1.4	2.2
Suiting B, green	Low conc.	1.1	1.3	0	0	1.3
	High conc.		0	1.3	1.3	1.3

[1]Sizing removed.

lowest of the finishes. Not all fabrics responded alike presumably because of differences in dyes.

An increase in the concentration of resin and starch decreased the color differences for green batiste. However, there were slight differences between concentrations in most cases.

In general, the effect of the finishes on fading was not great enough to be important in the choice among these finishes.

EFFECT OF FINISHES ON STRENGTH DURING STORAGE

There is a popular belief that cotton textiles should be stored unstarched to avoid deterioration and yellowing. The truth of this assumption has not been demonstrated. No reports have been found of studies which determined the effect of starch and other finishes on the strength of cotton fabrics when stored.

Rogers and Hays (7) stored bleached sheeting with the original sizing and with the sizing removed for 48 months at average temperatures of 78° F. and 102° F. The lower temperature was considered room temperature and the higher simulated that of an attic. They found storage at 102° F. produced significantly greater loss in strength than at 78° F. in warp and filling for both sized and desized sheeting. The sheeting containing the sizing was weaker than the desized sheeting in warp and filling at both temperatures. Although sizings contain starch they also contain other materials which may affect the strength of cotton fabrics when stored. Therefore, the effect of starch alone was not determined.

Even in time of increasing air-conditioning in homes, many people store household textiles and clothing in an attic during seasons when they are not in use or even for several years before they are passed on to others. The question is frequently asked if treasured articles such as christening robes, baby clothes, family heirloom quilts and similar textiles can safely be stored in an attic for considerable time and if it is advisable to store them unstarched. This portion of the study was undertaken to help answer these questions.

In the present study six fabrics with no finish and with each of the four finishes were stored in an attic and in a vault opening off a textile laboratory. The fabrics were wrapped in laundered white broadcloth. Recording thermometers were used at each location.

Other than to change the temperature charts once each week, the door of the vault was seldom opened. No provision was made for heating or ventilating the vault. A third set of fabrics was kept for the same period of time in a laboratory where there was no air-conditioning but normal fluctuations of temperature. No record was kept of the temperature in this laboratory. In all locations the fabrics were shielded from light.

There was much greater daily fluctuation of temperature in the attic than in the vault. This is understandable as the attic was well ventilated with louvers on three sides, therefore, it heated quickly on hot days and cooled rapidly in the night. An attic fan was sometimes used to hasten the expulsion of hot air from the attic and to replace it with the cooler night air. The attic was above a one-story house, had adequate head room for standing, was floored, but not insulated and was covered by a cedar shingle roof.

At all locations the fabrics were stored between July 12, 1956 and September 22, 1958, a period including three summers.

The range in temperature in the attic was from 47° F. to 115° F. with an average temperature of 80° F. There were 116 days when the temperature reached 100° F. or above, Table 5. The range in tempearture in the vault was from 55° F. to 102° F. with an average temperature of 76° F. On 8 days the temperature was 100° F. or above.

The ravelled strip method was used to determine the breaking strength of each fabric. The average of 10 breaks for the warp and the average of 10 breaks for the filling were considered the strength for that fabric. Strength was determined for each fabric with and without a finish before storage and for the same fabric after storage. Any changes in strength were assumed to have been caused by storage. Any differences between the strength of the unfinished and finished fabric were attributed to the finish.

The warp breaking strength of each fabric before storage and after storage in each of the three locations is given in Table 6. The average strength of the six fabrics with each finish at each location is given at the bottom of the table.

The application of CMC, resin and starch slightly increased the strength of all fabrics over the same fabric with no finish but there was no change where plastic was added as shown by the strength before storage. The differences are slight but are consistent among the fabrics.

With no finish added the six fabrics which were stored in the attic had all gained slightly in strength, an average of 2 pounds, which is not significant considering the variation within each fabric. After storage in the vault the strength

TABLE 5. CONDITIONS OF FABRIC STORAGE

Item	Attic	Vault
Number of days stored	756	756
Maximum temperature °F	115	102
Minimum temperature °F	47	55
Average maximum temp. °F	87	76
Average minimum temp. °F	73	75
Average temperature °F	80	76
Days 100°F and above	116	8

TABLE 6. WARP BREAKING STRENGTH OF FABRIC BEFORE AND AFTER STORAGE IN THREE LOCATIONS

Fabric	Storage	Finishes									
		None[1]		CMC		Plastic		Resin		Starch	
		Pounds									
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Batiste, blue	Before storage	34	±1.5	36	±1.0	34	±1.2	36	±1.7	35	±0.8
	Attic	35	±1.6	34	±0.9	35	±1.2	38	±1.3	37	±1.0
	Vault	34	±1.2	35	±1.0	34	±1.3	38	±1.8	35	±2.4
	Laboratory	34	±1.8	33	±0.8	34	±1.5	39	±1.5	35	±0.7
Batiste, white	Before storage	36	±1.4	38	±1.8	36	±1.7	38	±2.4	37	±2.3
	Attic	39	±1.1	37	±1.6	38	±0.8	41	±1.2	39	±1.2
	Vault	38	±1.5	37	±0.6	38	±1.3	41	±3.4	39	±0.8
	Laboratory	37	±1.0	36	±1.6	36	±1.3	40	±1.5	38	±1.0
Percale, blue	Before storage	50	±1.7	52	±1.3	50	±2.5	53	±2.0	51	±3.3
	Attic	51	±2.5	51	±3.0	53	±1.8	56	±1.9	53	±1.6
	Vault	51	±2.0	52	±1.9	54	±1.7	55	±1.2	54	±2.2
	Laboratory	49	±1.7	51	±1.9	51	±1.6	53	±1.8	52	±1.8
Percale, yellow	Before storage	50	±2.6	52	±2.2	50	±1.5	53	±1.5	51	±2.0
	Attic	53	±2.5	45	±2.2	48	±1.0	52	±2.0	50	±1.7
	Vault	53	±2.2	48	±1.8	48	±2.8	50	±1.0	49	±1.4
	Laboratory	51	±0.9	46	±1.7	46	±2.1	49	±1.6	49	±2.0
Suiting, green	Before storage	55	±3.0	58	±2.2	55	±2.4	58	±1.9	56	±1.5
	Attic	57	±2.5	58	±4.0	58	±2.8	58	±2.7	60	±1.7
	Vault	59	±1.9	58	±2.2	56	±1.9	58	±2.5	60	±2.0
	Laboratory	56	±2.1	56	±1.7	56	±3.9	60	±2.2	59	±2.0
Suiting, white	Before storage	66	±2.3	69	±3.5	66	±3.6	70	±2.2	67	±2.2
	Attic	68	±2.6	61	±3.8	67	±2.5	67	±2.6	68	±1.9
	Vault	66	±1.4	65	±3.2	65	±3.4	68	±2.8	67	±2.0
	Laboratory	66	±3.1	65	±2.4	65	±1.8	69	±2.6	66	±3.5
Average	Before storage	48.5	±2.1	50.8	±2.0	48.5	±2.2	51.3	±2.0	49.5	±2.0
	Attic	50.5	±2.1	47.7	±2.6	49.8	±1.7	52.0	±2.0	51.2	±1.5
	Vault	50.2	±1.7	49.2	±1.8	49.2	±2.1	51.7	±2.1	50.7	±1.8
	Laboratory	48.8	±1.8	47.8	±1.7	48.0	±2.0	51.7	±1.9	49.8	±1.8

[1]Sizing removed.

of the finished fabric was slightly greater for four fabrics, and the same for two fabrics, but the differences are not significant. After storage in the laboratory the strength of two fabrics was unchanged, three increased and one decreased but none was changed significantly.

After storage in the attic five fabrics finished with CMC showed a slight loss in strength but one had not changed. When stored in the vault four had lost slightly and two had not changed. Storage in the laboratory resulted in a slight loss in strength for the six fabrics. On the basis of averages the fabrics with CMC stored at each of the three locations were slightly but not significantly weaker than before stored.

Five fabrics with plastic finish were stronger and one weaker after storage in the attic but the differences were not significant. Three fabrics were slightly stronger, two weaker and one not changed after storage in the vault. Laboratory storage resulted in greater strength of two fabrics, lower in two and no difference in two fabrics.

When resin-finished fabrics were stored in the attic the strength was increased for three, decreased for two and unchanged for one fabric. When stored in the vault the strength of three fabrics was increased, of two fabrics it was decreased and of one not changed. After laboratory storage the strength of three fabrics was slightly higher, of two slightly lower and one was unchanged.

Five of the starch-finished fabrics were slightly stronger and one slightly weaker after storage in the attic. After storage in the vault three fabrics were slightly stronger, one weaker and two unchanged. Three fabrics were slightly stronger, two slightly weaker and one unchanged after storage in the laboratory.

On the basis of averages the fabrics finished with CMC lost slightly more in strength than the fabrics with the other finishes. The greatest losses were for the yellow percale stored at the three locations, the white suiting stored in the attic and the blue batiste stored in the laboratory.

It is possible to make 110 comparisons between the fabrics stored in the attic and the same fabrics stored in the vault. Of these 110 comparisons the t values showed there were significant differences at the 5 percent level or below in 28, in 17 of which the fabric stored in the vault was stronger and in 11 the fabric in the attic was stronger. However, for most of the comparisons, 82, there was no significant difference between the strength of the same fabric at the two locations.

None of the finishes significantly affected the strength of the fabrics when stored at any of the three locations and there was no difference between the locations in effect on strength. It is possible that there was not sufficient difference between the temperature of the attic and the vault to affect strength in three years of storage. However, there were 108 more days when the temperature of the attic reached 100° F. or above than in the vault.

There was no perceptible change in color of any fabric with any finish during storage. Although certain of these finishes, particularly starch, may attract silverfish, no other reason for not using them was found.

It appears reasonable to conclude that it is safe to apply any of these finishes to a fabric before storage and to store it for at least 3 years in the attic of an average house. The results offer no evidence to support the theory that laundered fabrics should be stored unstarched to prevent a change in color or loss in strength.

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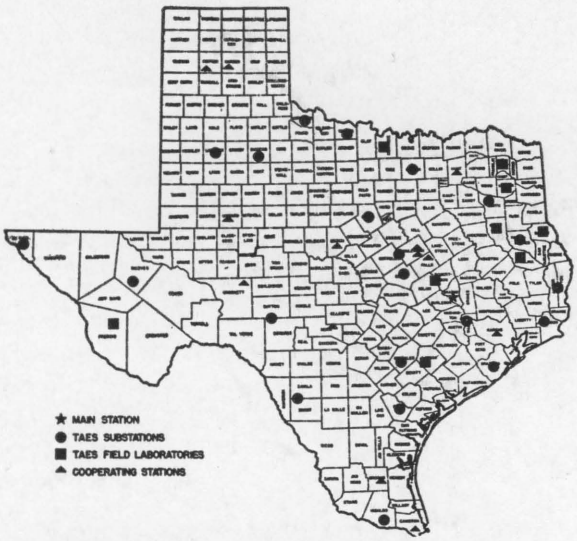

Location of field research units of the Texas Agricultural Experiment Station and cooperating agencies

State-wide Research

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The Texas Agricultural Experiment Station is the public agricultural research agency of the State of Texas, and is one of ten parts of the Texas A&M College System

ORGANIZATION

IN THE MAIN STATION, with headquarters at College Station, are 16 subject-matter departments, 2 service departments, 3 regulatory services and the administrative staff. Located out in the major agricultural areas of Texas are 21 substations and 9 field laboratories. In addition, there are 14 cooperating stations owned by other agencies. Cooperating agencies include the Texas Forest Service, Game and Fish Commission of Texas, Texas Prison System, U. S. Department of Agriculture, University of Texas, Texas Technological College, Texas College of Arts and Industries and the King Ranch. Some experiments are conducted on farms and ranches and in rural homes.

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THE TEXAS STATION is conducting about 400 active research projects, grouped in 25 programs, which include all phases of agriculture in Texas. Among these are:

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Conservation and use of water
Grasses and legumes
Grain crops
Cotton and other fiber crops
Vegetable crops
Citrus and other subtropical fruits
Fruits and nuts
Oil seed crops
Ornamental plants
Brush and weeds
Insects
Plant diseases
Beef cattle
Dairy cattle
Sheep and goats
Swine
Chickens and turkeys
Animal diseases and parasites
Fish and game
Farm and ranch engineering
Farm and ranch business
Marketing agricultural products
Rural home economics
Rural agricultural economics

Two additional programs are maintenance and upkeep, and central services.

Research results are carried to Texas farmers, ranchmen and homemakers by county agents and specialists of the Texas Agricultural Extension Service

AGRICULTURAL RESEARCH seeks the WHATS, the WHYS, the WHENS, the WHERES and the HOWS of hundreds of problems which confront operators of farms and ranches, and the many industries depending on or serving agriculture. Workers of the Main Station and the field units of the Texas Agricultural Experiment Station seek diligently to find solutions to these problems.

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